Evaluation of the Silviculturally Treated Program

Prepared for

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1. INTRODUCTION

1.1 BACKGROUND

The Silviculturally Treated (ST) program was initiated by the Ministry of Forests (MOF) in 1985 to provide information on growth and yield of treated stands across the province. Permanent sample plots (PSPs) were established using a matrix defined by silviculture treatment, species, Biogeoclimatic zone, stand age, and site index. The program now includes 487 PSPs, 135 of which have been re-measured on a 10-year cycle (Appendix I).

In 1993 the ST program was suspended[1] because of concerns that the program would not meet its original objectives to provide data for growth modeling and to determine treatment response in treated stands. A 1994[2] program review concluded the data were potentially suitable for some forms of model development, but the ST plots did not adequately represent treated stands and could not be used to monitor the population of treated stands. Furthermore, the data could not be used to assess the response to silviculture treatments. The review recommended the ST program continue, but with several modifications including: 1) restating objectives to reflect use of data for some growth modeling; 2) future installations should include pre-treatment measurements; and most importantly, 3) the ST program should be reassessed in a provincial strategy to obtain growth and yield data for model development.

Action has not been taken on the 1994 recommendations and the ST program remains suspended. However, data collection issues for growth and yield model development, monitoring, and assessing operational treatment response have not changed.

Since 1994, the MOF has embarked on two new initiatives that may affect the future of the ST program. First, the MOF has designed and adopted a new Vegetation Resources Inventory (VRI). Second, the MOF is developing a provincial growth and yield monitoring program. Both of these could provide some of the information that the ST program was intended to provide.

1.2 OBJECTIVE

The objective of this project was to re-evaluate the ST program considering recent developments, including VRI methods and the provincial growth and yield monitoring program. The review assessed the ability of the program to provide data for growth and yield model development and to meet silviculturists needs to obtain feedback on treated stands.

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[1] No new plots will be established, however, existing plots will be re-measured.

[2] J.S. Thrower and Associates Ltd. 1994. A review of operational growth and yield monitoring in British Columbia. Contract Report to the BC Ministry of Forests by Eleanor R.G. McWilliams and James S. Thrower. September 1994. 23 pp. (See Appendix 2 for a summary of this report.)

1.3 Process

The project objective was met in four steps:

1) Consult with modelers to:
   a) Determine if the ST program provides the data required for model development.
   b) Gather suggestions to modify the ST program (if necessary). The model developers included Barry Snowden and Abdel-Azim Zumrawi (Prognosis), Ken Mitchell (TASS), Rob Drummond (VDYP), Steve Titus and George Harper (MGM), and Don Reimer (SPS/FPS).
2) Compare the ST program with the Inland Northwest Growth and Yield Cooperative (INGY) and the Stand Management Cooperative (SMC) data collection methods.
3) Consult with silviculture foresters (Pat Martin and Jeff McWilliams) and researchers (Phil Comeau and Balvinder Biring) regarding the need for growth and yield information in silviculturally treated stands.
4) Develop recommendations for the future of the ST program.

1.4 Terms of Reference

This report was completed under contract to the MOF Resources Inventory Branch by our team including Eleanor McWilliams, *MSc, RPF*, A.Y. Omule, *PhD, RPF*, Jim Thrower, *PhD, RPF*, Ian Cameron, *MF, RPF*, and Bill Warren, *PhD*.

2. CONSULTATION WITH MODEL DEVELOPERS

Discussions with model developers are summarized as:

1) Concerns were expressed regarding suitability of the ST data for model development including:
   a) Lack of pre-treatment measurements. This means it is difficult to estimate pre-treatment stand structure conditions, and thus is difficult to locate the stand on a response surface or to model stand structure dynamics.
   b) No controls. This makes it impossible to accurately estimate treatment response. These estimates are needed to develop and validate TASS and SPS predictions of treated stand growth.
   c) Subjective location of the ST plots. Thus it is not possible to define the population that the plots represent. Ideally, plots located in operationally treated stands would be representative of the operationally treated population.
   d) Only a sub-set of heights measured. The data is more valuable for model development if all heights, including small trees, are measured. For Prognosis, in particular, the small tree sub-model is height driven (i.e., a height is predicted for each tree and then a dbh is assigned using a height-diameter equation).

2) When asked if the ST data could be used, the modelers response was that for TASS and SPS it was "highly unlikely", while for Prognosis and MGM "it has a potential for limited use." For Prognosis, the data would be useful for developing and calibrating the large tree diameter-growth component.

3) For developing TASS or SPS, it is preferable to spend money on well-designed trials rather than continue with the current ST program, even if new plots were established prior to treatment. However, if new plots were established prior to treatment, the data would be useful for SPS validation and calibration.

   The ideal data for developing TASS projections for complex stands comes from a few large (up to 1.0-ha) stem-mapped plots with as many trees measured for dbh and height as possible. Large plots are preferred for model calibration and validation because of the high diversity in complex stands. In contrast, for developing Prognosis, data representing a wide range of conditions is preferable (as is the objective of the ST program) rather than a few large well designed trials. Prognosis does not explicitly model treatment response.

4) There was unanimous support for a provincial strategy to obtain model development data[3]. It is an important issue that should be vigorously pursued. It was agreed that the future of the ST plots should be evaluated in the overall context of a provincial strategy. A coordinated strategy should provide for time and cost-efficiencies and provide a larger presence when applying for funds.

3. COMPARISON WITH INGY AND SMC

3.1 STAND MANAGEMENT COOPERATIVE (SMC)

The stated mission of the Stand Management Cooperative is:

> *"To provide a continuing source of high-quality information on the long-term effects of silvicultural treatments and treatment regimes on stand and tree growth and development and on wood and product quality."*[4]

As such, their focus is on determining treatment responses both in terms of wood quantity and quality. The SMC focuses on coastal Douglas-fir and western hemlock and examines a wide range of sites for these species. All SMC installations contain a set of plots with randomly assigned

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[3] In 1991, the Forest Productivity Council Technical Advisory Committee (FPC TAC) proposed a matrix for research growth and yield installations to cover major tree species, treatment, and biogeoclimatic zone combinations. This should be reviewed during the development of a provincial strategy to obtain model development data. (Development of a matrix for research growth and yield installations. Report to the FPC of B.C., Approved by TAC Feb. 28, 1991.)

[4] Source: SMC web site: http://www.cfr.washington.edu/smc/

treatments (including a control). This allows treatment response to be estimated. The ST program does not estimate treatment response, but it does encompass a much wider range of site, species, and treatment combinations. These are the fundamental differences between the SMC program and the ST program.

3.2 Inland Northwest Growth and Yield Cooperative (INGY)

INGY was established in 1984 and includes industry, states/provinces, tribal councils, private consulting firms, federal agencies, and universities interested in growth and yield in the Inland Northwest of the US. The INGY database has data from a variety of sources including continuous forest inventories, thinning trials, fertilization trials, levels of growing stock (LOGS) trials, and seedling survival plots. Recently INGY has focused on establishment of installations to study small trees and competing vegetation. These installations consist of several plots with treatments (including a control) randomly assigned. There are no data in the INGY database that are similar to the ST program.

4. CONSULTATION WITH SILVICULTURISTS

Silviculturists want re-measured plots established in treated stands to attain feedback on stand performance. Currently, the ST program is the only option available to do this (outside of establishing research trials). If the ST program was to be discontinued, silviculturists would demand an alternative program to track growth of treated stands.

Ideally, silviculturists would like to know treatment response. They would like to know what they have bought with their silviculture expenditures and whether or not the treatment is having the desired effect. Some silviculturists recognize the problems in estimating treatment response, others do not. This makes it difficult to communicate the inferences possible from different data collection methods.

Additionally, there is a strong belief that growth and yield researchers can use data from any plot established in treated stands. Our evaluation of the ST program shows that this is not always the case.

5. RECOMMENDATIONS

1. Discontinue the ST program.

Rationale –Modelers interviewed suggested that the ST data have limited use. ST plots do not meet silviculturists needs for feedback on the performance of treated stands. As a result, the value of the data does not warrant further expenditures.

a) *Documentation of existing ST plots should be maintained.*

Rationale - The initial investment in the plots should be protected and the option held for possible future re-measurements. It is not necessary to protect the plots from future operational treatments. This may provide more valuable information because then a pre-treatment measurement would exist. Plots should not be protected from harvesting, as their value is not deemed high enough. However, with plot locations well documented, the option will exist for a final re-measurement prior to harvest.

b) *Existing ST plots should be examined to see if they fill information gaps.*

Rationale - For plots without density control, the lack of a pre-treatment measurement does not preclude determining stand structure prior to treatment. These plots potentially have a higher value relative to plots in thinned stands. However these plots need to be evaluated against other available data in similar stand, site, and treatment combinations.

c) *To meet model development needs, future plot establishment in treated stands should be done prior to treatment.*

Rationale – Pre- and post-treatment measurements will quantify the type and intensity of treatment and allow those variables to be included in a response surface. This will make the information more valuable for model development and for checking model projections.

2. Develop an overall strategy to collect data for growth and yield model development.

Rationale - The MOF supports development of several growth and yield models. A coordinated strategy is required to obtain development data in a timely and cost-efficient manner. Growth and yield modellers should decide their future data needs and coordinate their efforts to meet those needs.[3,5]

[5] All model developers spoken to unanimously and strongly support this view.

Modelers suggest that ST data might be used to develop some components of Prognosis and MGM models, but it is not likely to be used in the development of TASS or SPS. A coordinated strategy would allow the relative value of the ST plots to be evaluated.

3. Address the needs of silviculturists for feedback on the performance of treated stands.

Rationale – Silviculturists have expressed the need for feedback on the performance of treated stands. Discussions with silviculturists revealed that most interpret "feedback" to be response-to-treatment information for a representative sample of treated stands. The ST plots do not provide either aspect of the desired information because they are not a representative sample of the population of operationally treated stands and cannot be used to estimate response to treatment.

A 1999 report[6] recently approved by the Growth and Yield Monitoring Task Force recommended:

> *"Growth (net) and yield of treated stands be monitored at the forest-level using the VRI approach to forest-level monitoring."*
>
> and
>
> *"Stand-level yield and net growth after treatment be monitored using modified silviculture surveys designed to enumerate stand conditions and estimate stand yield."*

Data from the GY monitoring program could be used to check the growth of treated stands against predictions or expectations. However it must be made clear that the GY monitoring program will not provide treatment response information. This information can be obtained in trials with randomization and replication of treatments and controls.

These recommendations should be reviewed with silviculturists. Effort is required to find a feasible linkage between legitimate needs of silviculturalists for feedback information and the technical challenges of collecting and analyzing basic data. In particular the recommendation to use modified silviculture surveys needs to be further detailed as there are many implications to be considered.

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[6] J.S. Thrower and Associates Ltd. 1999. Interim report: Monitoring growth and yield of treated stands. Contract Report to the BC Ministry of Forests Inventory Branch. 18 pp.

6. LITERATURE CITED

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Ministry of Forests 1990. Memorandum from Manager, Growth and Yield Section, Inventory Branch (Jon Vivian) to Terry Honer, Exec. Sect. For. Prod. Councils of B.C. Subject: Permanent Sample Plots in Operationally Treated Stands. Min. For. Inv. Br., Victoria. 2 pp. File 730-9-2-4.

Ministry of Forests 1993a. Memorandum from Directors of Inv. Br. (Dave Gilbert) and Silv. Br. (Henry Benskin) to the Chief Forester (John Cuthbert), et al. Re: Growth and yield monitoring for silviculturally treated stands. Min. For., Victoria. 2 pp. +attach. File 280-20/GYST.

Ministry of Forests 1993b. Interoffice Memorandum from Inventory Branch Forest Mensurationist (Stephen Omule) to Inventory Branch Manager of Growth and Yield Section (Jon Vivian). Subject: Monitoring plots. Dated Jan. 10, 1993. Min. For. Inv. Br., Victoria. 1 pp.

7. APPENDIX I – HISTORY OF THE ST PROGRAM

7.1 OBJECTIVES

The ST program was initiated in 1985 to provide information about the growth and yield of silviculturally treated stands across the Province. Treatments considered under this program were: planting, brushing and weeding, conifer release, juvenile spacing, fertilization, rehabilitation, sanitation spacing, mistletoe control and commercial thinning. The original objectives of the program were that PSPs established in silviculturally treated stands were to (Ministry of Forests 1985):

> *"monitor the rates of growth, mortality, changes in stand structure and stand development to rotation."*

These objectives were further clarified by Inventory Branch for the FPC TAC as to (Ministry of Forests 1990):

1. *"sample recognized populations in treated stands, to establish rates of growth, mortality and changes in stands structure from establishment to maturity or cutting age"*
2. *"provide treated stand growth and yield data to calibrate growth models of various resolution"*
3. *"assess operational growth response due to intensive forestry practices and provide guidance in the allocation of funding between stand tending and pest management programs, and"*
4. *"provide data suitable for special investigative studies."*

7.2 IMPLEMENTATION

Stands chosen for the ST program were identified by District Resource Officers in Silviculture and Inventory to represent current treatments. Stands were not considered if site and species composition varied greatly, if they were too old for a minimum of two measurements (at 10 year intervals), or if they were too small to accommodate a sample (Ministry of Forests 1985, 1989). Plots were located in suitable treated stands along a line projected through the middle of the stand at a distance between 30-200 m, depending on the size of the area, with the exact distance for the first plot chosen from a random number list.

7.3 PLOT DESIGN AND METHODS

Initially a cluster of three PSPs was located in each chosen stand after it had been treated (Ministry of Forests 1985). The original intent was to combine the ST program with the multi-phase inventory sampling program being introduced at that time. This program included air photo measurements at phase one, ground sampling for inventory at phase two, and ground sampling for growth and yield at phase three. The objective was to superimpose the three ST PSPs over the

inventory six point (prism plots) samples where possible. Plots two, four and six would be converted to PSPs under the ST program and plots one, three, and five were to be destructively sampled for volume and decay studies. Other ST PSP clusters were located independently so they could be combined with multi-phase inventory samples at a future time. There were 139 clusters of three plots located between 1985 and 1988 using these methods.

In 1989 the methodology changed from using three plot clusters to establishing a single plot in each chosen treated stand. This change was based on recommendations from the Forest Productivity Council TAC. In addition, stands were to be chosen according to the Forest Productivity Council's matrix for treated stands. Total number of plots established to date using both methods are provided in Table 1 by species and treatment, and in Table 2 by year and Forest Region. Note that the 3 plot clusters established between 1985 and 1988 are recorded as a single sample.

From 1985 to 1988 when the 3 plot clusters were established plot sizes were chosen in an attempt to obtain 70 trees greater than 7.5 cm dbh in a single plot. With the switch to a single plot in 1989 the objective was to obtain 90 trees greater than 7.5 cm dbh in each plot. From 1985 to 1991 subplots were established to tally trees from 7.4 cm dbh down to 30 cm in height. In 1991 the dbh cutoff between the main plot and the subplot changed from 7.5 cm to 4.0 cm. Subplots then tallied trees from 3.9 cm dbh down to 30 cm in height.

Sample trees were selected for height and age measurements; all trees were not measured for height. From 1985 to 1988 sample trees were selected by choosing dominants and codominants plus additional trees to cover the dbh range down to 2 cm dbh. Subsequently, top height trees were chosen based on the 100 largest dbh per ha definition. Additional sample trees were also chosen to cover the dbh range. All trees measured for age were also measured for height.

Table 1. Distribution of active ST plots by species and treatment. Data from Forest Productivity Council header database.

Species	---	N	NT	NF	NTF	NTPr	NTFPr	PI	PIT	PIF	PITF	PITPr	PIPr	Total
Red alder pure	1		1											2
Red alder mixed conifer	1	1												2
Trembling aspen pure	1	1						1						3
Trembling aspen mixed conifer		1	1		1			1						4
Birch mixed deciduous								1						1
Cottonwood pure	12							3						15
Cottonwood mixed conifer								1						1
Other deciduous spp.		1												1
Balsam spp. pure	2	5	1					5						13
Balsam spp. mixed conifer	1	13	4					1						19
Balsam spp. mixed deciduous			1											1
Cedar pure			1					1						2
Cedar mixed conifer	1	2	2					1						6
Cedar mixed deciduous									1					1
Cypress pure		4												4
Douglas-fir pure	8	5	18		1	1	1	8	1				3	46
Douglas-fir mixed conifer	9	3	7			1		2						22
Douglas-fir mixed deciduous	3		1					3				1		8
Hemlock spp. pure	3	8	1			1		1	2					16
Hemlock spp. mixed conifer	9	11	2		2			5						29
Larch spp. pure			2											2
Larch spp. mixed conifer		1	3											4
Lodgepole pine pure	60	40	41	1	9	1	3	8	8	1			4	176
Lodgepole pine mixed conifer	7	4	2			1		4	1		1		1	21
Lodgepole pine mixed deciduous	3		2										1	6
Spruce spp. pure	14	4	2			1		16	3				1	41
Spruce spp. mixed conifer	9	6	4					3						22
Spruce spp. mixed deciduous	1	4	2			5		4			1			17
White pine mixed conifer		2												2
Total	145	116	98	1	13	11	4	69	16	1	2	1	10	487

--- No information, N=natural origin, PI=planted, T=thinned or spaced, F=fertilized, Pr=pruned

Table 2. Number of plots established under the silviculturally treated program by Region and year. (data from Forest Productivity Council PSP header database.)

Year	Cariboo	Kamloops	Nelson	Prince George	Prince Rupert	Vancouver	Total
1985				5			5
1986				6	10	1	17
1987	7	1		7	28	2	45
1988	22		3	11	31	5	72
1989				7		4	11
1990		5	12	13	20	19	69
1991	25	28	17	24	13	24	131
1992	25	29	3	25	36	16	134
1993			1				1
1994				1			1
1995						1	1
Total	79 (16%)	63 (13%)	36 (7%)	99 (20%)	138 (28%)	72 (15%)	487 (100%)

7.4 CURRENT STATUS OF ST REMEASUREMENTS AND DATA

All plots are being re-measured on a 10-year measurement cycle. Of the plots established between 1985 and 1988, 43 are completely processed and available on the PSP Master files, while 92 are still being processed within Inventory Branch.

None of the re-measurement information has been entered into the Forest Productivity Council header database. In addition, as is evident in Table 1, the header database information related to plot establishment is not complete, 32% of the plots do not have treatment identified and additional 24% are coded as natural origin with no treatments. As a result, in the FPC header database, 56% of the plots have missing treatment information.

7.5 DEVELOPMENTS AND CONCERNS

The objectives and methods of the ST program were questioned around 1986. The concerns were that "*the current monitoring plots have limited analytical value because of the inherent bias in the design of the sampling plan*", and specifically that:

1. *"The permanent sample plots are located in stands that are subjectively located"*
2. *"The plot locations are conspicuous; there is a tendency to treat stands with plots differently from neighbouring stands without plots."* (Ministry of Forests 1993a).

The main use of the data from these plots was identified as (Ministry of Forests 1993b):

1. *"Providing feedback on the performance of treated stands under operational conditions; and"*

2. *"Quantifying the incidence, frequency, probability and dynamics of extraneous factors (e.g. pest damage) that reduce potential stand yield."*

Concerns were that the data from this program would not meet these needs and did not represent the average growth of stands under operational conditions (Ministry of Forests 1993b). This resulted in the suspension of plot establishment under the ST program in 1993 pending a complete review (however, re-measurement of existing plots was to continue).

7.6 Current ST Matrix Definition

In establishing plots under the ST program the objective was to subjectively choose stands to fill the defined silviculturally treated matrix. The current matrix is defined in a hierarchical fashion by BEC zones, treatment, species, age class, SI class, and density class. Within each BEC zone there are a set of species and treatment combinations. Age classes are defined separately for coniferous and deciduous species. SI classes are defined separately for coastal and interior BEC zones. Finally within age classes there are density classes. The intent was to aim for 3 plots per cell if the species is abundant in 3 or more BEC zones, or 5 plots per cell if the species is not common in 3 or more BEC zones.[7]

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[7] Joe Braz, Ministry of Forests Inventory Branch, personal communication, August 26, 1999.

8. APPENDIX 2 - 1994 REVIEW OF THE ST PROGRAM

The following sections (8.1 – 8.5) are taken directly from "A review of operational growth and yield monitoring in British Columbia", JS Thrower & Associates (1994).

8.1 MEETING THE ORIGINAL OBJECTIVES

There are four stated objectives for this program.

1. *"sample recognized populations in treated stands, to establish rates of growth, mortality and changes in stands structure from establishment to maturity or cutting age"*

   While the plots do provide "rates of growth, mortality and changes in stand structure from establishment to maturity or cutting age", they do this only for subjectively chosen portions of individual stands and therefore cannot be assumed to represent "recognized populations". In order for a sample to represent a population it must be randomly or systematically located to avoid the inevitable biases associated with subjective location.

2. *"provide treated stand growth and yield data to calibrate growth models of various resolution"*

   Given that under this program single plots are subjectively located in stands subjectively chosen to represent a range of operational treatments, data from these plots are suitable for model development and calibration. The one major drawback is that since they are established after treatment it is impossible to know the initial conditions. Knowing the pre-treatment conditions would make them much more valuable for this purpose.

3. *"assess operational growth response due to intensive forestry practices and provide guidance in the allocation of funding between stand tending and pest management programs,"*

   Given that plots are established after treatment and that there are no control plots, it is impossible to use these data to "assess operational growth response due to intensive forestry practices" or further to "provide guidance in the allocation of funding between stand tending and pest management programs".

4. *"provide data suitable for special investigative studies."*

   It is possible that data from these plots could be used for special investigative studies, although it is not possible to fully evaluate this potential without knowing the types of special studies envisioned.

8.2 EXPECTATIONS

In addition to the stated objective other expectations of the ST program were that it would provide:

1. Data to develop OAFs (operational adjustment factors);
2. Data to localize model projections; and

3. A general check on how the operational stands were growing.

These expectations cannot be met because of the subjective location of plots. In addition, these expectations indicate a general lack of clear communication of the intentions of this program.

8.3 Current Use of the Data

The data have never been used for any analytical purpose. The reason for this is that the first remeasurements are not scheduled to take place until 1995.

8.4 Potential Use of the Data

Data from these plots can be used to calibrate growth and yield models to predict the growth of stands *that are similar to the plots*. Due to the subjective location of the plots they cannot be assumed to represent the stand in which they are located. Therefore, the data cannot be used to calibrate models to predict the growth of the stands in which the plots are located. Treatment response information will not be provided from these data as pre-treatment measurements were not taken and there are no plots established in control areas.

8.5 Recommendations for the Silviculturally Treated Program

The ST program should continue to clarify program objectives and potential use of the data.

a) Data from the ST program are suitable for some forms of model development and calibration, but do not provide a representative sample of the population of all treated stands. The program objectives should be re-written to clearly state this and emphasize this is not a monitoring program.

b) Future installation of plots should include pre-treatment measurements. This will greatly increase the usefulness of the data for growth and yield modeling.

c) The future of this program should be addressed in a Provincial strategy for obtaining model development data.

8.5.1 Rationale

These plots are subjectively located and therefore do not represent the average of the population of treated stands. However, subjectively located plots are suitable for some forms of model development and calibration. The efficiency of subjectively located plots increases when installed using a response surface approach that ensures that conditions extremes are included in the sample.

8.5.2 Implementation Strategy

a) Clearly define the objectives of the program, the intended use of the data, and the scope of inference of the program. This should be followed by a statement of where the data cannot be used to avoid future confusion and misguided expectations.

b) Involve current and future potential users of the data in discussions of a Provincial model development data strategy.